

Groundwater Filtration Using **Stropharia Mycelium**

Phase 1

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Groundwater Filtration Using Stropharia Mycelium

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Abstract

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Groundwater contamination is a massive problem in developing third world countries. Current solutions are too expensive to be applicable in third world countries. This research attempts to inexpensively purify groundwater by examining the effect of Stropharia Mycelium on pH, Phosphate, and Chloride levels in groundwater. To conduct the research, a groundwater simulator was made using a series of plastic trays and urban soil. Rainwater was collected, poured into the simulator, and drained to make simulated groundwater. The simulated groundwater was the control and it was tested for Chlorides, Phosphates, and pH. To determine the effect of Stropharia Mycelium, the simulator was colonized with Stropharia Spawn and the groundwater simulation was repeated. The test groundwater was compared with the control groundwater and the results were that Stropharia Mycelium decreases Chlorides and Phosphates in simulated groundwater and increases the pH of simulated groundwater. The Stropharia Mycelium was able to purify the simulated groundwater and make it safer to drink. This research could easily be implemented to purify groundwater worldwide.

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Introduction

Water is life and mankind is going to all extents when it comes to contaminating it. Oil and gas storage tanks, septic systems, road salts, fertilizers, pesticides, and landfills are amongst the greatest contributors to groundwater contamination¹. Groundwater is vital for our existence. Not only does it quench the thirst of more than 50% of all Americans, but it also irrigates over 60% of the crops that make their way onto our dining tables every night¹. It is also used to fill public pools and power fire hydrants nationwide². Groundwater recharges many bodies of water and if contaminated, it can devastate the delicate ecosystems in those bodies of water. It is an essential part of our environment yet we continue to contaminate it. Groundwater contamination is a serious problem that could have catastrophic consequences if it is not solved soon.

The solution to groundwater contamination could be what you might have had for dinner last night-mushrooms. Mushrooms are just a small product of an intricate network of hyphae known as mycelium⁵. Mycelium is the vegetative part of a fungus which is made up of thread like hyphae that branch outwards⁴. Mycelium of the *Stropharia* mushroom has been able to remove *E. coli* and various other bacteria from wastewater and mycelium of the Oyster mushroom has been able to remediate a patch of soil saturated with oil³.

The experiment is designed to determine the effect of *Stropharia mycelium* on urban groundwater. To test the hypothesis, a groundwater simulator was created with a sample of urban soil in it. Rainwater was poured into the groundwater simulator and after it leached through the urban soil, it essentially became groundwater. The control of this experiment is the simulated groundwater (without *Stropharia mycelium*) which was tested for its pH, Chloride, and Phosphate levels. To determine the effect of *Stropharia mycelium*, the simulation was run

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conducted again but this time, the urban soil in the groundwater simulator was colonized with *Stropharia mycelium*. The resulting groundwater was tested and the results were compared with the control to determine the effect of *Stropharia Mycelium* on urban groundwater.

The experiment has the potential to improve water quality for residents of many developing countries. Colonizing the soil in developing countries with *Stropharia mycelium* could possibly lead to cleaner and safer water for its residents. The conclusion could remediate devastated aquatic ecosystems, save cities and house owners thousands of dollars in water pipe repair, and improve drinking water quality.

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Background Research

pH levels are a measure of the acidity of water. The pH levels of water have a great impact on the organisms living in that water. The scale ranges from 0-14 with a pH of 7 indicating neutrality, a pH greater than 7 indicating a base, and a pH of less than 7 indicating acidity⁶. pH levels are ultimately a measure of the relative amount of free hydroxyl and hydrogen ions in the water. Water with more free hydrogen ions is acidic and water with more free hydroxyl ions is basic⁶. Pure water has a pH of 7 before it comes into contact with outside substances. Neither a high pH level nor a low pH level is preferable. A low pH level will corrode metals and other substances. A high pH level can result in a bitter taste and cause for water pipes to become encrusted with deposits. pH levels in groundwater systems range from 6-8.5. Most organisms have a desired pH level but when industrial sewage and fertilizer runoff change the pH level, it devastates them and their ecosystem.

Phosphates are a vital nutrient in small quantities for aquatic plants and animals. A minor increase in Phosphates could set off a catastrophic chain of events. Water treatment plants, failing septic systems, and runoff from fertilized lawns are all sources of phosphates⁴. Phosphates begin to cause damage when they enter bodies of water and increase eutrophication⁴. Eutrophication is the enrichment of a body of water with chemical nutrients. Phosphates over-fertilize the plants in the body of water and the plants begin to die in larger quantities than they can be decomposed. After thousands of years, the buildup on the floor of the body of water starts to make the body of water shallow. The body of water starts to age faster than it can be replaced by nature. Phosphates can also cause excessive growth of algae and thus ruin the balance in the aquatic ecosystem. It can have drastic consequences for aquatic wildlife.

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Chlorides are commonly found in abundant quantities in seas and oceans but fresh water bodies generally contain very low amounts of them. Organisms that are accustomed to low levels of chloride are severely harmed when chloride levels increase in their environment. Salting roads during snowstorms, agricultural runoff, wastewater from water softening, and wastewater from industries and municipalities are all sources of chlorides. As water containing chloride evaporates, it leaves the chlorides behind and thus the chloride begins to concentrate. Chlorides in high concentrations can cause damage to metals.

Mycelium is the vegetative part of a fungus which is made up of thread like hyphae that branch outwards⁵. The fungus uses the mycelium to absorb nutrients from its environment. The hyphae secrete enzymes which break down the food source into smaller units and then it absorbs the food source using facilitated diffusion⁵. In an experiment done by Paul Stamets, Oyster Mycelium rehabilitated an infertile patch of soil saturated with oil and made it fertile³. The Oyster Mycelium was able to feed on the oil particles in the soil and make the soil fertile. In another experiment also done by Paul Stamets, *Stropharia mycelium* was planted near the run-off of a leaking septic tank which contained water infested with *E. coli* and other bacteria. When he tested the water a year later, it was a hundred times cleaner³.

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Hypothesis

The hypothesis is that *Stropharia mycelium* will be effective in decreasing Phosphate and Chloride levels and increasing pH levels in groundwater. Oyster Mycelium has been able to remediate a patch of soil saturated with oil³. *Stropharia mycelium* has been able to remove E. coli and other bacteria from water³. The reasoning behind the hypothesis is that the enzymes that *Stropharia mycelium* secretes to kill bacteria and E. coli will be effective in reducing Phosphates and Chlorides and increasing pH in the groundwater. *Stropharia mycelium* and Oyster mycelium are very alike hence the *Stropharia mycelium* will to some extent remediate the soil that comes into contact with rainwater. Groundwater is often polluted because of rainwater leaching through dirty soil. If the *Stropharia mycelium* fails to remediate the rainwater, it can always remediate the soil which in return would decrease the Phosphate and Chloride levels and increase the pH levels in the groundwater.

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Materials

- 8 Trays
- Electric Drill
- Urban Soil
- 2 Vials
- Lysol Disinfectant Wipes
- Rainwater
- Ruler
- Stropharia Mushroom Spawn
- Spray Bottle
- Measuring Cups
- pH Water Testing Kit
- Phosphate Water Testing Kit
- Chloride Water Testing Kit
- Warm Water
- 4 Gridded Fences
- Notebook
- Pen
- Scissor
- 4 Garbage Bags
- Safety Goggles

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Procedure

*-Requires adult supervision and safety goggles

1. *Drill 3 holes in each of the three rectangular grooves in the tray
2. *Drill a hole in each of the 6 spherical grooves in the tray
3. Repeat steps 1 & 2 with three more trays
4. Place each tray with holes drilled into it, onto a tray with no holes drilled into it with a grid fence in the middle thus creating 4 groundwater simulators
5. Fill each groundwater simulator $\frac{3}{4}$ of the way with urban soil
6. Pour 1 cup of rainwater on top of the soil in each top tray of the groundwater simulators.
7. After 1 hour, pour all the rainwater (which should have leached through the soil and into the holes) from the bottom tray of each groundwater simulator into a sanitized vial
8. Label the vial "1"
9. Test the water from Vial 1 for its pH, Phosphate, and Chloride levels
10. Record your results
11. Dispose of the soil from all groundwater simulators
12. Thoroughly wash both trays of each groundwater simulator with warm water and then wipe with Lysol disinfectant wipes
13. After the trays have dried, recreate the groundwater simulators

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14. Fill each groundwater simulator $\frac{1}{4}$ of the way with urban (polluted) soil
15. Add a layer of *Stropharia* spawn (as thick as the previous layer of soil) on top of the soil in each groundwater simulator
16. Add a layer of urban soil (as thick as the previous layer of soil) on top of the *Stropharia* spawn in each groundwater simulator thus creating a spawn to soil mass ratio of 1:2
17. Cut out 36 holes 1 inch wide in four garbage bags thus creating humidity tents
18. Place a groundwater simulator in each of the humidity tents and seal the bags
19. Water each groundwater simulator using a spray bottle each day for 30 days
20. After the *Stropharia* spawn has colonized the simulator, repeat steps 6 & 7
21. Label the vial "2"
22. Test the water from Vial 2 for its pH, Phosphate, and Chloride levels
23. Record your results

Controlled Variable(s): Rainwater, Soil Quality, Groundwater Simulator

Responding Variable(s): pH levels, Chloride levels, Phosphate levels

Manipulated Variable(s): Colonization of *Stropharia mycelium*

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Result

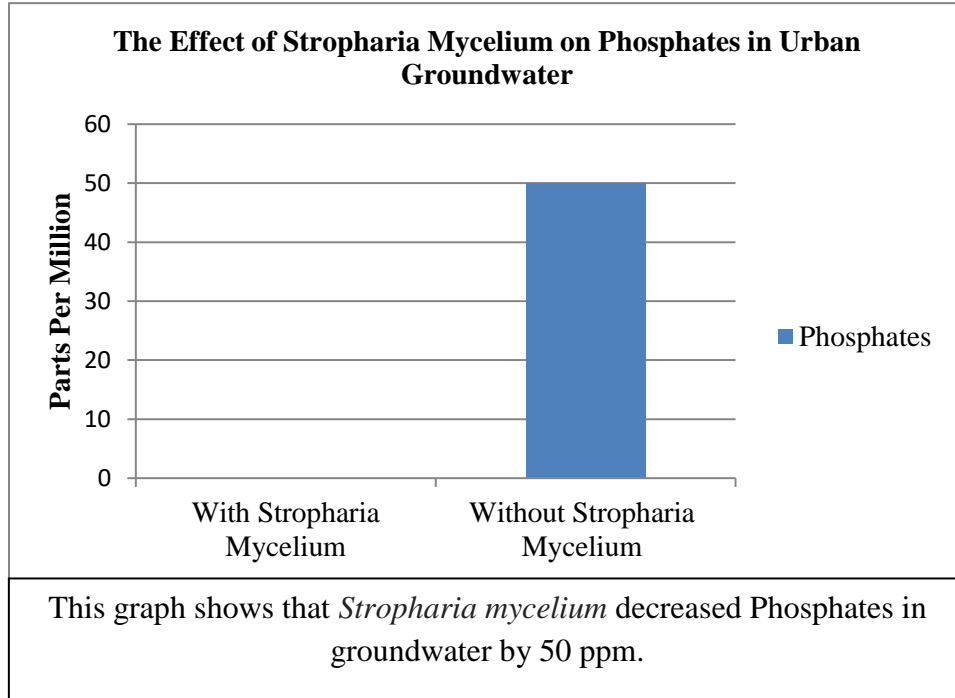


Table 1: The Effect of Stropharia Mycelium on Phosphates in Urban Groundwater

	With Stropharia Mycelium	Without Stropharia Mycelium
Phosphates (ppm)	0	50

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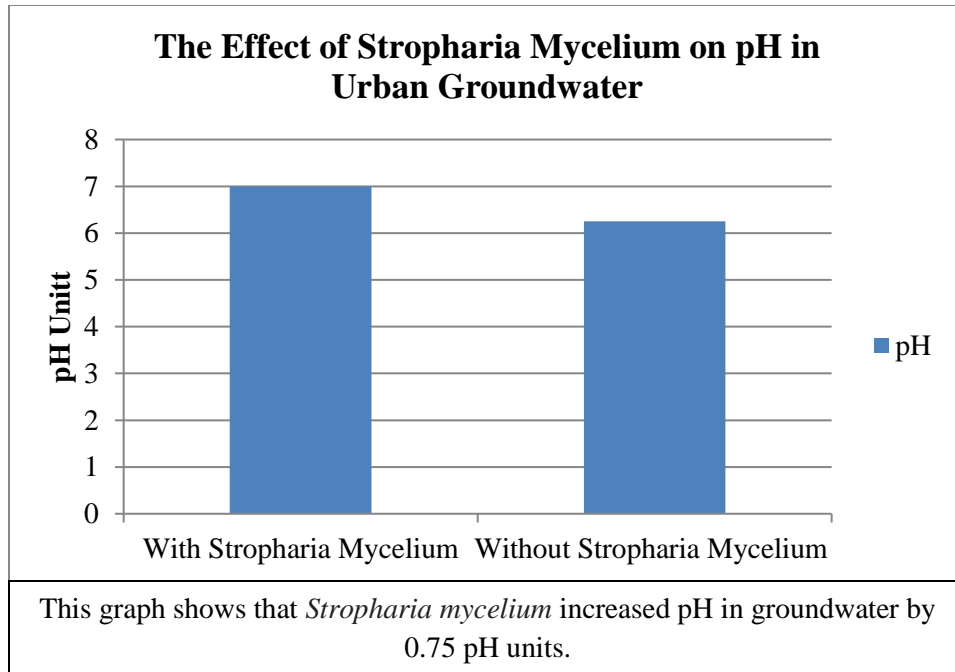


Table 2: The Effect of Stropharia Mycelium on pH in Urban Groundwater		
	With Stropharia Mycelium	Without Stropharia Mycelium
pH (pH unit)	7	6.25

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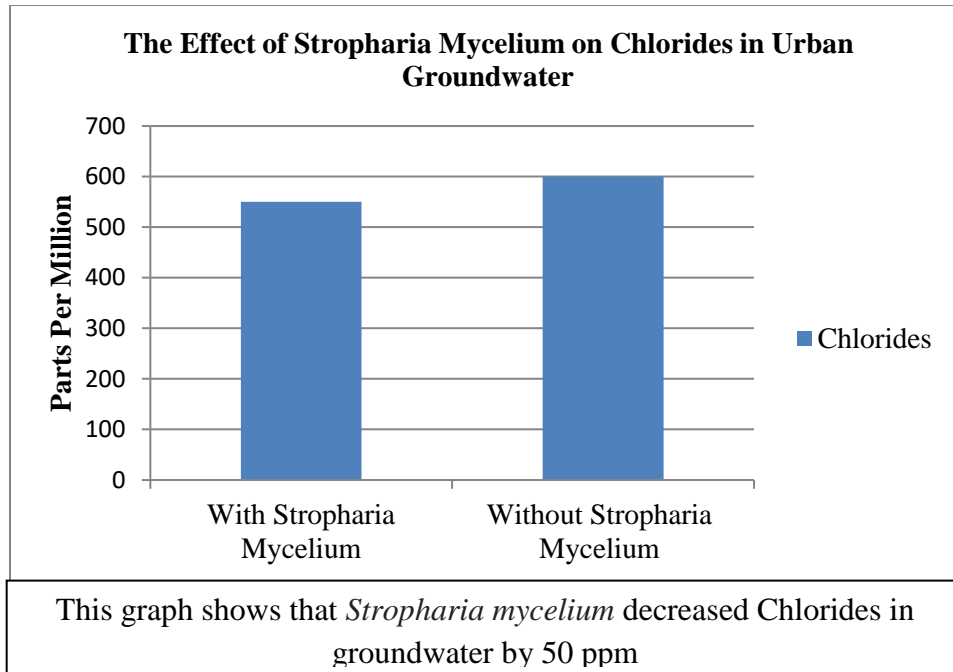


Table 3: The Effect of Stropharia Mycelium on Chlorides in Urban Groundwater		
	With Stropharia Mycelium	Without Stropharia Mycelium
Chlorides (ppm)	550	600

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Discussion

The results indicate that *Stropharia mycelium* decreases Phosphates and Chlorides and increases pH in urban groundwater over a period of approximately 30 days. There was an increase in pH from 6.25 to 7 (Tab. 2), a decrease in Phosphates of 50 ppm, from 50 ppm to 0 ppm (Tab. 1), and a decrease in Chlorides of 50 ppm, from 600 ppm to 550 ppm (Tab. 3). A decrease in unnatural Phosphates in groundwater would reduce eutrophication in natural bodies of water thus increasing the body of water's life. Also a decrease in unnatural phosphates in groundwater would prevent delicate aquatic ecosystem from being devastated. A decrease in unnatural Chlorides in groundwater would save home owners thousands of dollars in water pipe repair. An increase in pH indicates a decrease in acidity and it isn't necessarily a good thing but nor is a decrease in pH. Different organisms have different requirements for their pH. However, the increase in pH is only minor hence living organisms wouldn't be immensely affected. In drinking water, safe levels of Chlorides are 250 ppm, pH is 6-8.5 pH units, and Phosphates are >0.1 ppm. *Stropharia mycelium* has been able to get Phosphate within safe levels, keep pH in safe levels, and reduce Chlorides but not enough that it would be within safe levels. *Stropharia mycelium* cannot entirely replace an industrial water purifier however it can reduce the workload of an industrial water purifier thus reducing its operating costs. *Stropharia mycelium* can be beneficial to the bodies of water that are recharged by groundwater. The bodies of water don't have a purifier to purify their water intake however *Stropharia Mycelium* can become that purifier. *Stropharia mycelium* can also be beneficial to residents of developing countries who don't have a purifier to purify their groundwater. The hypothesis that *Stropharia mycelium* will be effective in decreasing Phosphate and Chloride levels and increasing pH levels in urban groundwater is supported by the data. The

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Stropharia mycelium was able to remediate the rainwater and/or the soil thus decreasing the Chlorides and Phosphates and increasing pH levels in urban groundwater.

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Conclusion

This experiment was done to determine the effect of *Stropharia mycelium* on urban groundwater. To conduct the experiment, a groundwater simulator was created with a sample of urban soil in it. Rainwater was poured into the groundwater simulator and after it leached through the urban soil, it essentially became groundwater. The control of this experiment was the simulated groundwater (without *Stropharia mycelium*) which was tested to determine its pH, Chloride, and Phosphate levels. To determine the effect of *Stropharia mycelium*, the simulation was conducted again but this time, the urban soil in the groundwater simulator was colonized with *Stropharia mycelium*. The resulting groundwater was tested and the results were compared with the control. There was an increase in pH from 6.25 to 7 (Tab. 2), a decrease in Phosphates of 50 ppm, from 50 ppm to 0 ppm (Tab. 1), and a decrease in Chlorides of 50 ppm, from 600 ppm to 550 ppm (Tab. 3). Nothing has interfered with the experiment. If the experiment were to be conducted again, samples of the simulated groundwater with and without *Stropharia mycelium* would be sent to a professional water testing laboratory to get more accurate results. The process of how *Stropharia mycelium* remediates groundwater would be studied at the molecular/chemical level to better understand the process. Also different Mushroom Mycelium would be tested to determine if any other mushroom can “perform” better. If the solution were to be applied in the real world and cities nationwide started colonizing city property with *Stropharia mycelium*, the city would save a lot of money on purifying groundwater, the city’s natural bodies of water would be healthier, and the city’s residents would have cleaner water to drink. If overgrowth were to occur with the *Stropharia mycelium*, it wouldn’t at all harm water quality. Rather it would be beneficial to the environment and society because *Stropharia* mushroom are edible and *Stropharia Mycelium* promotes growth of other plants.

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Future Work

Algae blooms are an increasing problem worldwide due to agricultural and industrial pollution. At a local reservoir, Jersey City Reservoir # 3, algae blooms frequently occur and have devastated the aquatic ecosystem at the reservoir. Algae blooms occur because of an unnatural increase in Phosphorus and Nitrogen. According to my results, *Stropharia Mycelium* can reduce Phosphorus in groundwater. I will implement my research at the reservoir to reduce Phosphorus in the reservoir water and prevent algae blooms from occurring. A solar powered submersible pump will pump polluted reservoir water onto a patch of a *Stropharia mycelium*. Water will be cleansed by the patch and drain into a collection pond, from which it will be drained back into the reservoir. Potentially dirty water will enter the filtration system and clean water will be pumped out. I have received permission from the governing body of the reservoir, the Jersey City Reservoir Preservation Alliance, to conduct my research at the reservoir. If my research is successful at a hostile, outdoor setting, such as the reservoir, it could with ease be successfully implemented at lakes worldwide to prevent algae blooms.

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